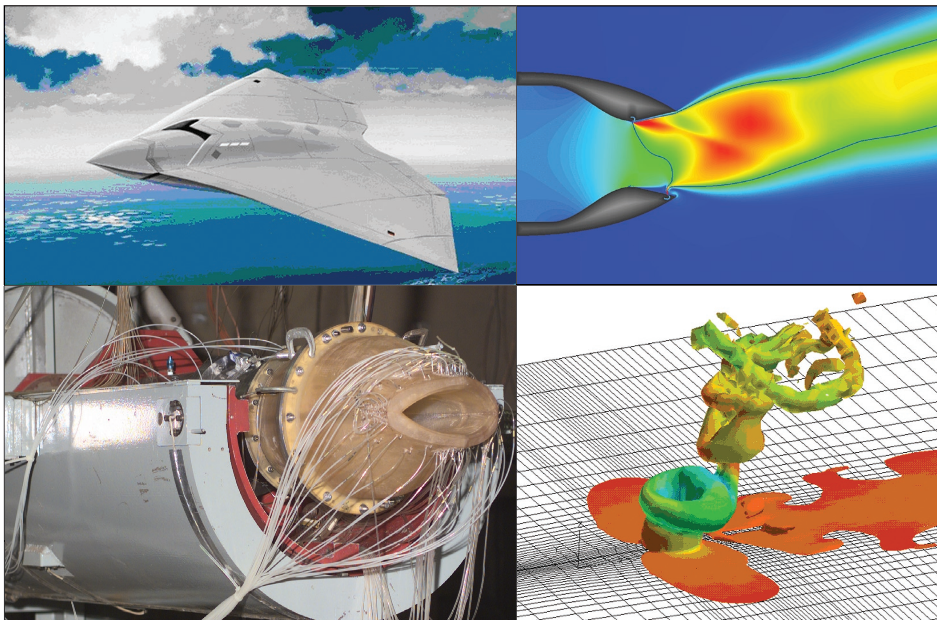
Air Force Research Laboratory | AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

RESEARCH LEADS TO LIGHTER WEIGHT UAV NOZZLE



Air Force Office of Scientific Research (AFOSR)-funded research is yielding computer-based models for fluid flows that are key enablers for developing new capabilities for the Air Force. Thanks to advances in computational fluid dynamics (CFD), Lockheed Martin Aeronautics engineers are developing fluidic thrust control for aircraft that provides thrust vectoring with no moving nozzle parts.

Many future unmanned air vehicles (UAVs) are tailless and will depend on thrust vectoring for flight control. The F-119 nozzle achieves conventional thrust vectoring using a mechanical system with moving flaps. Fluidic "fixed-geometry" thrust vectoring can result in substantial weight savings for aircraft. Lockheed Martin studies show that fluidic thrust control could boost control power for tailless UAVs, while slashing nozzle weight and cost in half.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

Under AFOSR sponsorship, the University of Calgary and Lockheed Martin collaborated on the development of CFD simulation methodologies used to identify promising concepts for nozzle flow control. Engineers used the CFD simulations to study the effect of pulsed fluidic control jets on the nozzle stream.

These fluidic injection techniques rely on the use of small control jets located in the nozzle wall to alter the flow direction of the nozzle stream by creating a "virtual" aerodynamic nozzle surface. The performance of this flow control technique depends on relationships among numerous geometric and fluid properties that were poorly understood.

Background

The University of Calgary and Lockheed Martin undertook a systematic study of both steady and pulsed-injection jets blowing into a nozzle crossflow using CFD methods. The CFD methodology involves dividing a flowfield into discrete volumes, or grid cells, and then applying a numerical algorithm with mathematical relationships governing fluid motion and a model of turbulent flow physics.

Prior research from AFOSR grants with Princeton's Professor George Mellor and Stanford's Professor Parviz Moin led to the development and use of physical models for turbulent flow in these studies. The CFD tools allowed these researchers to explore parameters, such as injection momentum, frequency, and geometry, more rapidly and less expensively than possible in a purely experimental approach.

The researchers compared the computational results to experimental data taken at the University of Calgary. Those comparisons also guided the choice of computational methods, thus ensuring accurate predictions.

AFRL is currently investigating thrust vectoring in structurally fixed nozzles based on this research effort. These tests demonstrated thrust vector angles of greater than 10º with good thrust efficiency.

The predictive capability of CFD was vital, since experimental evaluation of the many possible concepts would cost an estimated $1 million more in the preliminary design phase. The researchers transitioned the critical features of the control jet and nozzle design to General Electric and Allison for an Integrated High Performance Turbine Engine Technology effort to build large-scale hardware for an engine demonstration of fluidic thrust control. The Air Vehicles Directorate estimated a 30-50% nozzle weight reduction using fixed nozzles with this technology.

Office of Scientific Research
Emerging Technologies

Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (03-OSR-07)